REMARKS

Claims 8-13 and 17-24 remain pending herein.

The abstract, specification and claims have been amended in the same manner as in the parent application and to identify the parent application.

Filed herewith is an Information Disclosure Statement listing all references cited during prosecution of the parent application.

Prompt and favorable examination of this application on the merits is respectfully solicited.

Respectfully submitted,

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Date

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Attachment:
Mark Up of Amended Abstract,
Specification, Claims

RWP/ame

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~~SPECIFICATION~~

BLOWER AND METHOD FOR MOLDING HOUSING THEREOF

Sub B1

This is a Rule 1.53(b) Division of application Serial No. 09/627,004, filed July 27, 2000, now allowed; which in turn is a Rule 1.53(d) Division application of Serial No. 09/090,944, filed June 5, 1998, now U.S. Patent 6,132,771.

Field of the Invention

The present invention relates to a blower.

Background of the Invention

Ins A1

Reducing equipment in size using electronic devices has ~~been prompting~~ prompted the use of high-density electrical circuits ~~to be used~~. Since the density of heat produced by electronic equipment increases with increasing density of electronic devices in it, axial-flow blowers or oblique-flow blowers are used to cool electronic equipment.

As shown in Fig. 11, in a conventional blower, an annular wall 2 is formed away from the end of a blade of an axial-flow fan 1, which rotates about a shaft 4, thus causing an air flow 5 from the suction side to the discharge side when a motor 3 is energized, that is, the blower is in operation.

When the blower is in operation, however, the velocity of the air flow increases on the back pressure side at the blade end, so that under the influence of secondary flows between blades, a low-energy region occurs on the blade trailing edge side, where the velocity is converted to pressure energy.

In the low-energy region, energy loss is significant and air flow easily separates from blade surfaces, over which

vortices occur, thus increasing turbulent flow noise. Thus the region poses a problem of an increase in noise level and a deterioration in static pressure-flow rate characteristic (hereinafter referred to as the P-Q characteristic).

The phenomenon mentioned above is frequently observed, especially when a fan exhibits stall conditions because large leakage vortices occur at the end of a blade under the action of flow resistance (system impedance) on the discharge side.

U. S. Patent ~~Application~~ No. 5707205, previously ~~filed~~ obtained by the applicant of the present invention, discloses that by sucking laminar air flow inside an annular wall through a slit ~~in it~~ therein when a blower is in operation, a blower inhibits leakage vortices and rotation stall from occurring at the end of a blade to improve the P-Q characteristic and reduce noise.

PCT-based Japanese Patent Laid-Open No. 6-508319 and U. S. Patent ~~Application~~ No. 5292088 disclose that a blower is arranged so that vortices of air flowing through a plurality of rings, spaced apart from each other around an axial-flow fan, increase the air flow rate.

U. S. Patent ~~Application~~ No. 5407324 discloses that a blower is arranged to make it possible for air to flow inside and outside a housing by inclining to the direction of air flow the internal perimeter of a plurality of annular plates, stacked around an axial-flow fan.

However, common blowers for personal computers and workstations, which are made rectangular with standardized dimensions to reduce their costs, have external dimensions of 60 mm square to 92 mm square. Thus it is not desired that a blower be significantly changed into a round shape by, for

example, making annular plates 7_1 to 7_5, forming the annular wall 2, circular as shown in Fig. 12.

U. S. Patent ~~Application~~ No. 5707205 also discloses a blower whose annular wall 2 is shaped so that its sections corresponding to the middle of the upper, lower, right, and left sides of a rectangular casing body 15 are flush with the casing body 15 as shown in Figs. 13a and 13b. However, only making the contour of the annular wall rectangular as shown in Figs. 13a and 13b causes the effect of sucking laminar air flow inside the annular wall through each slit 6 to be slightly lessened, compared with an annular wall which has a round contour as shown in Fig. 12. Thus the effect of improving the P-Q characteristic and reducing noise cannot fully be provided. The casing body described by U. S. Patent ~~Application~~ No. 5707205 also has a problem of low mechanical strength and the like, because the sides of the annular wall are thinner than the other sections.

Every blower mentioned above improves a fan characteristic by sucking air around a fan. The applications only describe the arrangement of rings (annular plates) around a fan, not the shape of the fan. To fully exhibit the characteristic of a fan, its shape must be devised.

A method has generally been used which predicts the performance of a fan or determines the three-dimensional shape of a fan appropriate for use conditions by cutting a fan blade through the surfaces of cylinders concentric with the axis of rotation of the fan, developing the surfaces, converting a fan blade into a plane infinite straight-line series, and applying to the series a straight-line airfoil system theory suggested for aircraft and the like.

Although U. S. Patent ~~Application~~ No. 5407324 discloses an arrangement of the rings, the arrangement is not acceptable in terms of mass productivity, strength, and accuracy.

Sub B4

It is an object of the present invention to provide a blower which exhibits an improved P-Q characteristic and reduces noise as a blower in Fig. 12 whose annular wall has a circular contour even when substituted for a conventional rectangular blower and which has practically necessary strength.

It is another object of the present invention to optimize the shape of a fan blade and that of an annular wall of a blower which sucks air inside the wall through slits provided therein to improve aerodynamic performance and strength and reduce cost by increasing mass productivity.

Disclosure of the Invention

First of all, an annular wall of a blower according to the present invention is described which is contoured in a non-circular shape including a rectangular shape. The present invention provides a blower characterized in that an annular wall is formed away from the ends of fan blades, and slits passing from the circular inner perimeter to the non-circular outer perimeter of the annular wall are provided in sections of the wall which are opposite to the ends of fan blades, whereby the flow rate of air flowing inside the annular wall through the slits is constant around the annular wall, although the distance between the inner perimeter and the outer perimeter varies with locations in the annular wall.

The blower is also characterized in that the flow rate of air flowing inside the annular wall through the slits is made constant all around the annular wall by continuously changing

the width of the slits, w, according to the radial length between the inner perimeter and the outer perimeter of the annular wall, L, so that the condition represented by the following equation or its close condition is met:

w^3/L = constant.

The blower is also characterized in that the flow rate of air flowing inside the annular wall through the slits is made constant all around the annular wall by changing the width of the slits, w, and the number of slits in the direction of the axis of rotation, n (n is a positive integer), according to L, so that the condition represented by the following equation or its close condition is met:

$n \cdot w^3/L$ = constant.

Specifically, the annular wall with the slits is arranged by stacking a plurality of annular plates in the direction of the axis of rotation of a fan, ~~said~~ the annular plates being separated from each other.

Sub B3

More specifically, the present invention provides a blower which sucks air inside an annular wall through slits as a fan rotates, the annular wall being formed away from the ends of fan blades, the outer peripheral sections of the annular wall which correspond to the ends of fan blades being formed to be ~~plane~~ planar and substantially flush with a rectangular casing body at the middle of upper, lower, right, and left sides of the body, and slits, passing from the circular inner perimeter to the non-circular outer perimeter of the annular wall, being provided in sections of the wall which are opposite to the ends of fan blades, characterized in that the equation $n \cdot w^3/L$ = constant is met, where the width of the slits is w, the number of slits in the direction of the axis of rotation is n (n is a positive integer) and the

distance in the radial direction between the inner perimeter to the outer perimeter of the annular wall is L, or alternatively the width of the slits, w, and the number of slits in the direction of the axis of rotation ~~is~~, n, are changed according to L so as to satisfy the close condition of said equation.

This arrangement enables the flow rate of air flowing inside the annular wall through the slits to be constant all around the annular wall even when a conventional blower with a rectangular contour is replaced with a blower of the present invention. Thus the P-Q characteristic is improved, and noise is reduced as is the case with a blower with a circular contour, shown in Fig. 12.

By disposing spacers forming and supporting the slits at or near the middle of the four sides of the casing body, the annular plates can be supported as well as weak sections of the annular plates can be reinforced.

Projecting toward the outer perimeter of the annular wall the spacers in the middle of the four sides of the casing body prevents the annular plates from being damaged or deforming under an undue load when a blower is installed.

Tapering the projected sections of the spacers along the axis of rotation increases the workability at the time of installing the blower.

Next, the shape of a blade of a blower fan according to the present invention is described. The present invention provides a blower that sucks air inside the annular wall also through the slits provided therein, wherein the shape of fan blades is improved and in this connection the shape of the housing is further improved.

The present invention improves aerodynamic performance, strength, and mass productivity, thus realizing cost savings.

According to a first aspect of the present invention, which aspect relates to a fan blade shape, a blower that is arranged so that air is sucked inside the annular wall through the slits provided therein is characterized in that a cross-sectional shape obtained by cutting a blade of a fan through the surface of a cylinder concentric with the axis of rotation of the fan is an airfoil and that the shape of the blade near the end thereof is formed to be an airfoil with respect to air flowing in through the slits. The blower is also arranged so that a blade at a section near its end becomes progressively thinner towards the end, and the location which provides the maximum thickness of the airfoil obtained by cutting the fan through the surface of a cylinder concentric with the axis of rotation gradually moves back toward the blade trailing edge side according as the location approaches the end of the blade. The blade advance angle *fÆ* is made larger near the end of a blade than in other locations, which angle is set to meet the following equation,

$$fÆ = \tan^{-1} (v/u)$$

where v is the average velocity of air flowing in from outside the annular wall, and u is the peripheral speed of a blade end. The blade advance angle near the end of a blade is set equal to the angle of a slit in the annular wall. The first aspect improves the P-Q characteristic and noise reduction performance.

According to a second aspect of the present invention, which aspect relates to the annular wall associated with a fan, a plurality of annular plates are stacked through spacers in the direction of the axis of rotation, ~~said~~ of annular

plates being separated from each other, to form the annular wall with slits, and one of the plurality of annular plates which is at the most upstream side of a main air flow produced by the fan is made thicker than the remaining annular plates. This arrangement significantly improves both the P-Q characteristic and the strength of the fan at a high level. In addition, by cutting the upstream-side end surface of the inner periphery of the annular plate on the most upstream side of the main air flow, the periphery becomes thinner, thereby improving blower performance.

According to a third aspect of the present invention, the clearance between the end of a blade and the inner perimeter of the annular wall is wider ~~according~~ as it gets farther away from a bearing support. This arrangement has the effect of preventing the dimensions from changing with time and the end of the fan blade from touching the inner perimeter of the annular wall due to initial dimensional variations.

According to a fourth aspect of the present invention, a plurality of annular plates are stacked in a spaced relation from each other through spacers in the direction of the axis of rotation to form an annular wall with slits, and the width of the slits is larger only near the spacers than in other locations. This arrangement cancels the effect of the spacers and improves the P-Q characteristic of a blower. Alternatively, the width of the slits near the spacers is made equal to or smaller than in other locations, thus fully improving the P-Q characteristic and reducing noise.

According to a fifth aspect of the present invention, notches are provided near the spacers in the outer perimeter of the annular plates so as to reduce the radial length of the

annular plates. This arrangement cancels the effect of the spacers and improves the P-Q characteristic of the blower.

According to a sixth aspect of the present embodiment, the number of spacers used to stack the annular plates is set at n (n is an integer equal to or larger than five), and at least (n-2) of the n spacers are disposed in parallel with each other. This arrangement increases the housing mass productivity, thereby contributing to cost savings. Further, inclining the spacers near four sides of a casing body with respect to the radial direction increases mass productivity and reduces cost while minimizing a deterioration in blower performance. Inclining the spacers in four corners of a casing body with respect to the radial direction is expected to exercise the same effect.

Chamfering or obliquely cutting the outer peripheral ends of the spacers inclined with respect to the radial direction improves blower performance.

According to the final aspect of the present invention, a blower housing molding method for molding a housing of the blower is provided which employs a pair of upper and lower molds for forming the inner surface of the annular wall and a boss, and a pair of slide cores sliding opposite to each other at right angles to the moving direction of the pair of molds, wherein the slits are formed all around the annular wall by said pair of slide cores at a time, and the annular wall with the slits, a base serving as a reference for installing the blower and the boss to which a motor is secured are molded respectively as a single piece. This method can increase mass productivity and reduce noise.

Figs. 25a and 25b are a side view and a front view of a housing of a seventh embodiment, respectively;

Figs. 26a and 26b are a side view and a front view of another housing of the seventh embodiment, respectively;

Figs. 27a through 27c are a side view and a front view of a housing of an eighth embodiment and a detailed cross-sectional view of a spacer for the housing, respectively;

Figs. 28a and 28b are a partially cross-sectional perspective view and a front view of a mold arrangement for the eighth embodiment, respectively;

Figs. 29a and 29b show the structure of a mold for molding a housing of the fifth embodiment, respectively;

Figs. 30a through 30c are a side view and a front view of a housing of a ninth embodiment and a detailed view of a spacer for the housing, respectively; and

Figs. 31a and 31b are a partially cross-sectional perspective view and a front view of a mold arrangement for the ninth embodiment, respectively.

Detailed Description

Referring now to the drawings, the embodiments of the present invention are described below.

~~(First embodiment)~~

Figs. 1a through 1c and Figs. 2 through 4 illustrate the first embodiment of the present invention. A blower in Figs. 1a through 1c has annular plates 7_1 through 7_4 attached to a casing body 15, which form an annular wall 2 surrounding an axial-flow fan 1. The annular plates 7_1 through 7_4 are stacked with spacers 8 in between to form a slit 6 between any two annular plates next to each other.

In Fig. 4, w is the width of a slit, L is the length of the slit, u is air velocity, and Q is the amount of incoming air through the slit per unit time. ΔP, not shown, expresses the pressure difference across the slit, that is, the difference between the atmospheric pressure and the pressure on the fan side. As shown in Fig. 4, the velocity profile in the slit is parabolic. The amount of incoming air through one slit per unit time, Q, is expressed as

$$Q = \Delta P \cdot w^3/(12 \cdot f\text{Å} \cdot L).$$

where fÅ is the viscosity of air. ΔP depends on the rotating speed of the fan. Since fÅ, the viscosity of air, is constant everywhere, a requirement for keeping Q constant is given by

$$w^3/L = \text{constant}.$$

The above equation shows that a well performing blower can be provided which inhibits blade vibration, disk circulation, and the like, thus eliminating a deterioration in the P-Q characteristic and an increase in noise, since reducing the value of w according to the above equation makes the amount of incoming air constant all around the fan on the four sides, where L is small.

~~(Second embodiment)~~

Figs. 5a through 5b show the second embodiment. In the first embodiment, the width of a slit, w, is continuously changed to keep flow resistance constant in the intervals 7s and 7r, with the same number of slits in the intervals 7s and 7r. In the second embodiment, on the other hand, the width of a slit, w, and the number of slits, n, are changed at the same time to keep flow resistance constant in the intervals.

Although in the first embodiment, air flow in a slit is assumed to be laminar, whether it is laminar or not depends

because the width of a slit, w, in the interval 7s can be made smaller than in the case of the first embodiment in exchange for increasing the number of slits in the interval 7s, n.

This arrangement provides a blower that restricts blade vibration and disk circulation to prevent a P-Q characteristic deterioration and reduce noise to its full extent.

The width of a slit 6 in the interval 7s is set larger at its ends (portions adjacent to intervals 7r) than in the middle of the interval 7s to reduce variations in the amount of incoming air at boundary points between intervals 7s and 7r where the number of slits changes.

Similarly, the width of a slit 6 in the interval 7r is set smaller at its ends (portions adjacent to intervals 7s) than in the middle of the interval 7r to reduce variations in the amount of incoming air at boundary points between intervals 7s and 7r where the number of slits changes.

~~(Third embodiment)~~

Fig. 6 shows the third embodiment. The blower has slits 6 in an annular wall 2 surrounding an axial-flow fan 1. Specifically, annular plates 7_1 through 7_5 whose four corners are cut to fit in a rectangular casing body 15 are stacked with spacers 8 in between, and a slit 6 is formed between any two annular plates next to each other.

The spacers 8 forming and keeping the slits 6 are four spacers 8a, which are in intervals 7r corresponding to the four corners of the casing body 15, and four spacers 8b, which are in intervals 7s located in the middle of the four sides of the casing body.

As described above, arranging the spacers 8b in the intervals 7s where the radial length of an annular plate, L, is shortest reinforces weak portions of an annular plate. The

where w and L are the width and length of the slit, respectively is met, makes constant the flow rate of incoming air through each slit all around a fan and provides a blower featuring a good P-Q characteristic and reduced noise.

The first embodiment and Figs. 8a, 8b, 9a, and 9b show three examples of an annular wall contour, any of which provides a blower featuring a good P-Q characteristic and reduced noise if the width of a slit is changed under the same conditions.

In the above embodiments, the width of a slit is continuously changed. On the other hand, when the width is intermittently changed as shown in Figs. 10a and 10b, better performance can be ensured, compared with Figs. 13a and 13b, in which the width of a slit is constant, though the performance is a littler lower, compared with Figs. 1a through 1c, in which the width of a slit is continuously changed. Intermittently changing the width of a slit as in Figs. 10a and 10b allows the contour of a slit to be simpler than continuously changing the width, so that the slit can easily be formed, thus leading to a low blower cost. Thus a high cost-per-performance blower can be provided.

~~(Fourth embodiment)~~

Figs. 14a through 14c show a blower of the fourth embodiment. As shown in Fig. 14c, the width of the annular plates 7_1 through 7_5, W, may be set equal or substantially equal to that of an axial-flow fan 1 in the direction of its axis. The width of each slit, w, is changed so that flow resistance is almost equal at every location.

Driving the axial-flow fan 1 to rotate it produces negative pressure on the back pressure side at the end of a blade, so that the pressure difference across the slit 6

causes an air flow 5 to go inwardly through the slit. Setting the width of a slit 6, w, to an appropriate value makes the air flow, going through each slit 6, laminar, which inhibits leakage vortices flowing from the positive pressure side to the back pressure side and eliminates flow separation on the back pressure surface of a blade. This, in turn, means that the P-Q characteristic is improved and that noise is reduced.

As shown in Fig. 15a, a conventional blade has a shape formed by radially jointing together blades whose cross-sections obtained by cutting them through the surfaces of cylinders concentric with the rotational axis are airfoils. This is because a conventional fan is designed, with radial air flow neglected. However, calculated values and actual values do not disagree widely as ~~far~~ long as a fan has an annular wall through which air does not come in from outside and the flow resistance of air is relatively low. To improve fan characteristic when the flow resistance of air is a little larger than in the case above, advance blades are generally used, the middle of which in the direction of their chords is inclined toward the direction of rotation.

In Fig. 15a, a thin line h is an equi-thickness line (line passing through locations at which a blade has the same thickness) showing the thickness of a blade, an alternate long and short dash line i is the center line of a chord which is provided when the blade is cut through the surface of a concentric cylinder, and a broken line k shows the locations at which the largest thickness is provided when the blade is cut through the surface of a concentric cylinder.

A combination of the conventional fan and a housing 17 with slits formed in the annular wall causes air to flow over the blades of the fan in the direction as indicated by an

arrow r in Fig. 15a. Fig. 15b shows the cross section of the blade taken along an alternate long and two short dashes line a-a□ along the air flow.

Because the blade is relatively thick near the ends thereof as shown in Fig. 15b, an air flow flowing in the surroundings of the end hits against the end surface, thus causing an air layer to easily separate near both edges t1 at the end.

The blade thickness distribution, on which the performance of a blade depends largely, is far from the thickness distribution of an ideal airfoil series. Thus airfoil effects are not likely to produce lift, and air layer separation t2 is ready to occur on the blade trailing edge side u2.

A conventional fan is described below in greater detail to compare it in arrangement with an axial-flow fan 1 of the present invention. The conventional fan is arranged as shown in Figs. 16a and 17a through 17d.

As shown in Fig. 16a, the cross sections of a blade of the conventional fan which are obtained by cutting the blade through the surfaces of concentric cylinders are a series of airfoils of the same system. For every cross section, blade advance angles ƒÆ1, ƒÆ2, and ƒÆ3 are the same which are made by a straight line p1, passing through the center of rotation of the blade, o, and the center line of the chord, i.

Blade thickness of a conventional fan changes along lines l-l□, m-m□, and n-n□ in Fig. 17a are as shown in Figs. ~~7b~~17b, ~~7c~~17c, and ~~7d~~17d, respectively.

Figs. 16b and 18a through 20 show an axial-flow fan 1 of the present invention provided by taking measures against these problems.

gradually moves back toward the trailing edge side u2 as the location approaches the blade end s.

Third, the blade advance angle ƒÆ3 near the blade end s is larger than that in other locations.

Fourth, the blade inclination angle of the blade end s matches the slit angle and is perpendicular to the axis of rotation.

As shown in Fig. 18b, the above arrangements allow the airfoil to fully exercise effects on air flowing in from outside the annular wall. Moreover, because of the arrangements, air smoothly flows through the slits to the blade ends, air flowing from the blade ends produces lift under the influence of the airfoil, and air layer separation is prevented on the blade trailing edge side. This means that the P-Q characteristic of the blower is improved, since air flowing through the slits can effectively be converted into air flow.

In the embodiment, the blade advance angle ƒÆ3 near a blade end should be set so that it satisfies the following equation:

ƒÆ3 = $\tan^{-1}$ (v/u)

where v is the average velocity of air flowing in from outside the annular wall, and u is the peripheral speed of the blade end.

The setting according to the above equation makes air flow from outside the annular wall almost parallel to the blade ends, thus helping air smoothly flow in. This is the most advantageous in improving the P-Q characteristic and reducing noise.

In the embodiment, the slits 6 in the annular wall 2 are formed in a plane perpendicular to the axis of rotation of the

fan. When the slits are inclined up on the leading edge side u1 (up the air flow 5) and down on the trailing edge side (down the air flow 5) as shown in Fig. 20, changing the inclination angle of the blade end continuously so that the angle is equal to the slit angle prompts air to smoothly flow in and improves the P-Q characteristic. In Fig. 20, the blades 16 are blade cross sections obtained by cutting blades at several locations along planes containing the axis of rotation 4.

~~(Fifth embodiment)~~

Figs. 21a through 21c show another embodiment of the housing 17. An axial-flow fan 1 is the case with the fourth embodiment. A housing 17 in the fifth embodiment is nearly the same as in the case of the fourth embodiment. The thickness t5 of the annular plate 7_5 on the top stage is larger than those of the other annular plates 7_1 through 7_4. The annular plate 7_5 differs from the others only in that the upper edge y of the inner surface of the annular plate 7_5 (the edge is up an air flow 5) is cut to be arcuate as shown in Fig. 21c and that the inner surface of the annular plate 7_5 is tapered so that the inner circumference progressively becomes longer toward its upper end. z represents the step formed between the upper and lower ends by tapering the inner surface.

As shown in Figs. 21a through 21c, the housing 17 has a boss 18, or a bearing support to which a motor is secured, and a base 19, a reference for blower installation. On top of the base 19, the annular plates 7_1 to 7_5, thin rings which are cut so that four straight sides are provided for each of them, are vertically jointed together with spacers 20 in between. All of these parts are formed from resin by injection molding so that they are monolithic.

In the embodiment, the step z is provided so that the clearance between the axial-flow fan 1 and the annular wall progressively becomes larger from the boss 18 to the top of the annular wall, that is, the internal surface of the annular wall is tapered to keep the clearance small while reducing the possibility that a blade end touches the annular wall when the axis of rotation of the fan inclines.

In the above embodiment, the upper edge y of the inner surface of the annular plate 7_5 on the top stage is cut to be arcuate, but the same effect is exercised even when the edge is cut to be C-shaped as shown in Fig. 22a or to be formed in a multistep fashion as shown in Fig. 22b.

~~(Sixth embodiment)~~

Figs. 23a and 23b show another embodiment of the housing 9. An axial-flow fan 1 is the case with the fourth embodiment. The housing in the sixth embodiment is almost the same as in the fifth embodiment but only differs from the housing in the fifth embodiment in that the housing in the sixth embodiment has expanded sections 30 where the width of slits 6, w, is further increased near spacers 20 supporting annular plates 7_1 through 7_5.

The strength of the spacers 20 are essential to providing the housing 9 in the embodiment with satisfactory strength. When the spacers 20 are thickened to make a housing strong enough, the spacers 20 prevent air from flowing from outside the housing 21, thus causing the P-Q characteristic to deteriorate and noise to increase.

Fig. 24a shows a slit 6 with a width w which is optimized under the condition below, using the radial length L of the slit 6 as a parameter:

w^3/L = constant.

become turbulent, thus contrarily lessening the effect of improving the P-Q characteristic and reducing noise.

As described above, according to the present invention, the strength of the annular plates decrease because they are partially thin. As shown in Figs. 23a, 23b and 24b however, the expanded section 30 whose inner surface is formed to be arcuate allows stress concentration to be modified and strength (especially breaking strength) to increase when the joint between a spacer and an annular plate is loaded.

~~(Seventh embodiment)~~

The seventh embodiment cancels the effect of spacers 13, using an arrangement differing from that used for the sixth embodiment. An axial-flow fan 1 is the case with the fourth embodiment. Figs. 25a and 25b show a housing 17 in the seventh embodiment. The seventh embodiment only differs from the fifth embodiment in that the housing 17 is provided with notches 33 so that the radial length of annular plates 7_1 through 7_5 is short near spacers 20.

For this arrangement, properly setting the dimensions of the notches 33 enables the effect of the spacers 20 on flow resistance to be eliminated and the P-Q characteristic of the blower to be fully exhibited as is the case with the sixth embodiment.

For the housing 17 in the seventh embodiment, the width of a slit 6, which does not sharply change unlike the width of a slit in the sixth embodiment, can be set by adjusting only the contour of the annular plates 7_1 through 7_5. Thus the housing 17 is relatively easy to form and suited for mass production.

The housing in Figs. 25a and 25b is provided only around the outer circumference of the annular plates 7_1 through 7_5

with the notches 33. Even when notches 34, including the outer surfaces of the spacers 20, are formed as in the housing 17 in Figs. 26a and 26b, the housing has a little lower strength but exercises one and the same effect.

~~(Eighth embodiment)~~

The fourth through seventh embodiments aim to improve the characteristics of a blower. On the other hand, although the eighth embodiment is a litter lower in performance than the other embodiments, it is intended to provide a high cost-per-performance blower by enhancing suitability for mass production and reducing part costs while minimizing a deterioration in performance.

Figs. 27a through 27c show a housing 9 of a blower in the eighth embodiment. An axial-flow fan 1 in the embodiment is the case with the fourth embodiment.

A housing 17 in the eighth embodiment slightly differs only in shape from that in the fifth embodiment. In Figs. 27a through 27c, the spacers 20 in the fifth embodiment are spacers 23a and 23b.

As shown in Figs. 27a through 27c, eight spacers are provided. Four of these spacers, or four spacers 23a in four base corners, are installed in the radial direction with respect to a boss while spacers 23b on four sides are installed at an angle of 45° to the radial direction. Six of the eight spacers are arranged in parallel to each other.

Disposing the spacers 23a and 23b in this way makes it possible to mold the housing 17 using a relatively simple arrangement of upper and lower molds 24 and 25 and two slide cores 26 shown in Figs. 28a and 28b. This mold arrangement is a common means for molding a blower housing, whose geometry is suitable for mass production.

On the other hand, a mold arrangement for the fifth embodiment in which all spacers are disposed in the radial direction needs at least upper and lower molds 24, 25 and four slide cores 26 as shown in Figs. 16a and 16b. For such a complicated mold arrangement, a mold cost itself is high. Moreover, molding equipment occupies a large space because of a large basic mold size, or the number of products molded using the same equipment is small. This reduces mass productivity and increases a housing production cost.

Since air flows in substantially in the radial direction from outside an annular wall when a blower is in operation, a spacer, if disposed to be inclined to the radial direction, blocks air flow, thus deteriorating blower performance. However, in the eighth embodiment, installing on the four sides, whose length in the radial direction is short, spacers which should be inclined allows the spacers to be short, so that the effect of the inclined spacers is minimized.

As denoted by a numeral 35 in Fig. 27c, when the outside of the spacers 23a on the four sides of the housing is chamfered, an increase in air flow resistance, a deterioration in the P-Q characteristic, and an increase in noise can be minimized.

~~(Ninth embodiment)~~

Figs. 30a through 30c show a housing 17 for a blower of the ninth embodiment. An axial-flow fan 1 in the embodiment is the case with the fourth embodiment. The housing 17 in the ninth embodiment slightly differs only in spacer shape from that in the eighth embodiment. In Figs. 30a through 30c, the spacers 23a and 23b in the eighth embodiment are spacers 27a and 27b.

moves toward a blade trailing edge side as the location approaches the end of the blade.

11. A blower according to claim 9, wherein the blade advance angle near the end of the blade is set larger than in other sections.

12. A blower according to claim 11, wherein the blade advance angle ƒÆ is set to satisfy the following equation:

ƒÆ = $\tan^{-1}(v/u)$

where v is the average velocity of air flowing in from outside the annular wall, and u is the peripheral speed of the end of the blade.

13. A blower according to~~ any one of claims 9 through 12~~ claim 9, wherein the blade inclination angle near the end of the blade is set equal to the angle of the slits provided in the annular wall.

14. A blower which is arranged to suck air inside an annular wall through slits as a fan rotates, the annular wall being formed away from the ends of fan blades, and the slits, passing from the inner perimeter to the outer perimeter of the annular wall at a section which corresponds to the ends of fan blades, being formed in sections of said annular wall which are opposite to said ends of the fan blades,

wherein said annular wall with the slits is formed by stacking a plurality of annular plates in a spaced relation from each other through spacers in the direction of the axis of rotation of the fan, and the annular plate that is located at the most upstream side of the main air flow produced by the

from each other through spacers in the direction of the axis of rotation of the fan, and at least (n-2) of the n spacers (n is an integer equal to or larger than five) are disposed in parallel with each other.

21. A blower according to claim 20, wherein among the spacers forming and supporting the slits, those spacers at and near the middle of the four sides of the casing body are inclined with respect to the radial direction.

22. A blower according to claim 20, wherein among the spacers forming and supporting the slits, those spacers in the four corners of the casing body are inclined with respect to the radial direction.

23. A blower according to ~~any one of claims 20 through 22~~ claim 20, wherein the outer peripheral ends of the spacers inclined with respect to the radial direction are cambered or cut obliquely.

24. A blower-housing molding method for molding a housing of the blower according to ~~claims 21 or 22~~ claim 21using a pair of upper and lower molds for forming the inner surface of the annular wall and a boss to which a motor is secured, and a pair of slide cores sliding opposite to each other at right angles to the moving direction of said pair of molds,

wherein the slits all around the annular wall are formed by said pair of slide cores at a time, and the annular wall with the slits, a base serving as a reference for installing the blower and the boss are molded as a single piece respectively.

ABSTRACT

The ~~object of the~~ present invention ~~is to provide~~ provides a blower that improves the P-Q characteristic and reduces noise. ~~An~~ The ~~apparatus according to the present invention~~ is a blower that sucks air inside through slits (6) provided in an annular wall (2), wherein the blade thickness near a blade end s is progressively reduced toward the front end, and the location F of the maximum thickness gradually moves back toward a blade trailing edge side u2 so as to make the blade advance angle near the front end larger than in other locations. In addition, the width of a slit is made wider in sections near a spacer than in other sections. Alternatively, notches are provided in the outer perimeter of annular plates near the spacers so as to reduce the radial length of the annular plates. This arrangement improves the P-Q characteristic and reduces noise.